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Characterization of heterogeneous near-surface materials by joint stochastic approach

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Using several geophysical methods to better constrain a diagnosis is a standard approach in many field studies. Generally data of each method are individually inverted and a global geological / hydro-geological interpretation is realized as a second step from separated inversion results. Thereby, contributions and limitations of each method to final interpretation are integrated after the inversion processes.

Consequently, the expertise of the one who performs the interpretation is decisive and its weight on the final result is difficult to quantify.
In the end, reliability of geophysical interpretation is mainly limited by the problem of non-uniqueness of solution, on one hand because of equivalency of some models and intrinsic methods resolutions, and on the other hand because the links between geophysical parameters and rock physics properties in heterogeneous media are not so straight and do not allow to clearly discriminate between two materials (or state of weathering, or water saturation, etc. . .).

Following the work of many authors in the past twenty years, we propose to jointly inverse several data types simultaneously in order to better constraint the inverse problem. We selected a set of geophysical methods, widely used to investigate the subsurface: vertical electrical sounding (VES), time domain electromagnetism (TEM), magnetic resonance sounding (MRS) and multi-channel analysis of surface waves (MASW). We particularly insist on how to objectively introduce the a-priori knowledge as an input in the algorithm. For a given geological environment, one can define a few hydrogeological facies each described by a statistical (normal, log-normal) distribution of classical geophysical parameters (electrical resistivity, water content, decay time, shear wave velocity).

To explore the model space, we propose a stochastic approach based on the Metropolis algorithm in order to provide a statistical estimation on the result uncertainties (due to the data quality, sensitivity and investigation depth of each method). Result of inversion is displayed as a statistical distribution of the geophysical parameters but also as a statistical distribution of the facies initially defined. The a-priori knowledge is hence quantitatively and objectively used to reduce the uncertainty of the interpretation.